Introduction to PS main power supply

• 1959

• 1968 “La nouvelle alimentation de l’aimant du synchrotron à protons du CERN”

05-12-2007

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History

• First MPS: BBC (6kA / 5.4 kV) 1959 – 1968
• Second MPS: SIEMENS (6kA / 10.8kV) 1968 – 2010
  – 1973: First insulation problem of the generator rotor
  – 1975: PS fire. BBC damaged and finally dismantled. No more spare system.
  – 1977: New generator rotor
  – 1978: First test of the 13 MVA back-up system (transformer connected to 18 kV), 14GeV
  – 1979: New thyristor rectifiers (replacing mercury valves)
  – 1982: New spare transformer for rectifiers (2*12 MVA)
  – 1993: New control system for excitation and motor speed (Simadyn)
  – 1993: New PLC control
  – 1996: New filtering capacitors
  – 2002-2004: PLC S5 -> S7
  – 2004: Broken fan blade on generator rotor (R2)
  – 2006: 26 GeV cycles done on 13MVA transformer
  – 2006: No generator spare rotor
MPS breakdown in 2004

• An earth fault appeared on the rotor of the generator during the run 2004.
• The maintenance was advanced for spring 2005 (instead of spring 2006).
• The fault was discovered in February 2005 and was due to a broken fan blade. All the fan blades suffered of fatigue.
• At this time, the solution to repair wasn’t known. The only solution was to install the spare rotor.
• SIEMENS was asked to repair the broken rotor
• The generator rotor had to be repaired in another building
• There was too much noise in the MPS room

Friday 21st April 06: transport to Hall 180

Back home… Wed. 24th May 06
Just in time!

Rotor repair by SIEMENS in 2006
During a 400 kV fault on May, 15th 2006, the team discovered some insulation fibers in the air shaft under the generator.

After expertise of Mr. Kruger (Siemens engineer), the decision was taken to change the rotors to avoid more degradations of the stator.

This rotor was not repaired due to cost (1.6M€).
Towards a new MPS

• 2003: Start of the studies to replace the rotating machine

• 2004: EPFL audit
  – Rotating machine ok!
  – Thyristor rectifiers + electronics to be changed!

• 2005: Report on SMES based power system (ITP Karlsruhe)
• 2005: Doctoral student on capacitor energy storage system (CERN-EPFL)

• 2006: Patent application (CERN – EPFL)
• 2006: Memo to DG
• 2006: DG White Paper included a new power system for the PS

• 2007: MS + IT3490/AB + FC5195 => Contract adjudicated to CONVERTEAM
• Alstom Power Conversion was sold to BARCLAYS Private Equity (UK)
• Now called CONVERTEAM since 2006
• Main sites: Massy – Belfort – Nancy (FR), Berlin (DE), UK
• 3800 persons / 750 M€
• Main markets: Marin(nº1 worldwide), oil & gas, industry, energy
• Contract awarded to CONVERTEAM: 10.28M€
  – First price 12.2M€ !!
  – Converters + design (48% FR)
  – Capacitor banks (37% CZ)
  – Transformer + installation (15% ES)

• The contract includes:
  – 2 years of warranty
  – 5 years of maintenance
  – A complete stock of recommended and compulsory spare parts after 2 years of operation
  – Cost: 1.05M€ (included in the 10.28M€)
Project name

IT-3490/AB

60 MW power system with capacitive energy storage for the PS main magnets

POPS

POwer for PS
POPS topology
How does it work?

Figure 1: PS chronograms for a 26 GeV/c cycle.
1: Voltage 2.5 kV/div
2: Current 1 kA/div
3: Active power 10 MW/div, at the magnet terminals.

Figure 2: Magnet Stored energy

Capacitors bank voltage

Resistive Losses and charger power

Figure 4: Power of the two chargers

Capacitors

12MJ
5kV to 2kV

R_{magnet} \times I^2

\frac{1}{2} \times L_{magnet} \times I^2

Losses: 500kW in water
165kW in air

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Hardware

• Main components: 18kV transformer / Capacitor banks / AC/DC & DC/DC converters
Capacitor banks

- 6 capacitor banks mounted in outdoor containers (24T, 12m*2.5m*2.5m)
- Capacitor units 1.96mF * 126 per bank = 247mF
- 5kV dry type
- Total 1.48 F / 5kV , 18.5 MJ
Power semiconductors

- AC/DC and DC/DC converters: converters for motor drives (10 MW)
- 2kA / 5kV
- Pres-pack IGBT (IEGT/Toshiba)
Converters

• One DC/DC converter (6kA / 1.7kV) = 2 * MV7000 (three-phase motor drive)
• 36 Tons of chokes !!! Mounted in cabinets and water cooled.
Where?

• Building 367
  – Inside for active devices
  – Outside for passive devices
• CERN will build the infrastructure
  – Concrete plateform with cable ducts
  – False floor
• CONVERTEAM will do the installation
POPS control

• Turnkey power system
  Hardware + software (PWM + interlock + power management + ....)
• HMI to be done by CERN
• Current loop to be done by CERN (FGC)
• CERN will build a model (60A/100V) of the system to validate the control
The project is managed by AB/PO
The representatives per activity are:

- AB/OP follow-up
  R. STEERENBERG

- Modelling & simulation
  M. Veenstra

- Project leader
  JP. Burnet

- Freising building 367
  JM. CRAVERO

- Infrastructure coordination
  C. COUPAT

- PS coordinator
  R. PRINCIPE

- Electricity
  C. JACH

- Civil engineering
  JA. OSBORNE

- Cooling
  Y. BODY

- A. Unnervik
  S. Baird
  Project follow-up

- Control
  Q. King
• Organization during the design phase

POPS chart
- POPS can only be tested on the main magnets
- The first power test is planned for November 2009
- POPS shall be in operation in 2010
Next steps

• I will organize meetings on different topics:
  – Access to and around building 367 + transport
  – How to connect POPS to the 18kV, 2 switchgears in ME6 ?
  – How to cool down POPS ? Dedicated cooling tower ?
  – Where to install SMH16, SMH26 ?
  – Control interface with CCC: PVSS ? Java ?
  – How to build a POPS model ?

• The drawings for civil engineering shall start as soon as possible (Jan/Feb 08)